MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Cheri Meyer, Project Manager
Revolving Loan Section, Resource Management Division

FROM: Marcus J. Tironi, P.E., District Engineer
Kalamazoo District Office, Water Resources Division

DATE: July 26, 2011

SUBJECT: City of Plainwell SRF Project No. 5355-01

The purpose of this memo is to confirm the basis for determining that the City of Plainwell SRF Project No. 5355-01 qualifies for the Green Project Reserve (GPR) funding under Public Law 111-88. This project will implement improvements to its existing wastewater treatment facility and incorporate green components that provide environmental benefits.

This project will utilize Moving Bed Biofilm Reactor (MBBR) technology to reduce energy consumption by over 20%. In addition, the consumption of natural gas will be reduced by 50% by utilizing a "waste-to-energy" process where anaerobic sludge digestion will produce renewable energy (biogas) that will be used to heat the reactors and buildings on site. Based on the information provided, this project qualifies for GPR funding.

City of Plainwell Wastewater System Improvements
SRF Project No. 5355-01
Summary of Green Components
July 2011

Summary and Overview of the Project

Provisions of the *2010 Clean Water and Drinking Water State Revolving Fund 20% Green Project Reserve: Guidance for Determining Project Eligibility Guidance*, dated April 21, 2010, indicate that a number of project components in the Plainwell Wastewater System Improvements Project are eligible for "principal forgiveness", or a reduction in the loan capital amount.

As presented in the SRF Project Plan, as supplemented July 2011, the City of Plainwell (City) has committed to implement necessary improvements to the City's wastewater system. Improvements are necessary in the collection system and at the Water Renewal Plant (WRP). The elements that qualify for Michigan's FY2012 *Green Project Reserve* are located at the WRP.

The Selected Alternative, entitled *Alternative 5 – Replace Existing Secondary Treatment System* (as Supplemented July 2011), incorporates several green components that will provide environmental benefits beyond those typically achieved at wastewater treatment facilities. The Selected Alternative is in keeping with the City's commitment to provide continued reliable wastewater service while pursuing innovative, environmentally attractive, and cost effective technologies. The City embraces environmental Best Management Practices that surpass ordinary utility practices and further the goals of the Clean Water Act.

Pursuant to the criteria outlined in the Guidance, the selected alternative exhibits *Green Project* benefits through categorical energy efficiency and innovative design, by:

1. Innovative: Improving production of renewable, clean energy by enhancing biogas production, and thereby reducing the consumption of fossil fuels by the WRP;
2. Energy Efficiency: Reducing energy consumption by over 20% thus reducing greenhouse gas emissions accordingly.
3. Energy Efficiency: Utilizing innovative energy efficient MBBR treatment technology in conjunction with reuse of existing facilities;

The City of Plainwell WRP Project meets the definition of a "Categorical GPR Project" under the "Energy Efficiency" guidelines where,

> "Energy Efficiency is the use of improved technologies and practices to reduce the energy consumption of water quality projects, use energy in a more efficient way, and/or produce/utilize renewable energy." [1]

The Project also meets the definition of a Categorical GPR Project" under the "Environmentally Innovative" guidelines by,

> "...demonstrating new and/or innovative approaches to delivering services or managing water resources in a more sustainable way."

This City of Plainwell project accomplishes all of the requirements of these definitions, summarized as follows, and further detailed below and in the references.

a) *Reduces energy consumption*:
MBBR is a highly-efficient attached growth process. When compared to five other commonly used treatment technologies, the carbonaceous MBBR process was found to be the most energy efficient.[2] MBBR is much more efficient than conventional return activated sludge and other suspended growth treatment processes because the attached growth media allows for a high population of biomass within a relatively small area.

The pairing of Moving Bed Biofilm Reactor™ (MBBR) with the re-use of the primary clarification/anaerobic digestion processes reduces WRP energy consumption by over 20 percent compared to recent traditional systems. This is proportionate to a 44 percent reduction of BOD loading to the secondary aeration process. This is accomplished by reduced aeration blower energy consumption, secondary tank size, and mixing energy. Typically the energy consumption of the secondary aeration ranges from 50 to 65 percent of the total treatment facility energy consumption.[3] The use of MBBR technology, in conjunction with high rate anaerobic digestion, further reduces the secondary tank size and mixing requirement by over 2.5-fold (250 percent), by employing attached growth biofilm efficiencies in the secondary treatment facilities.[4]

As detailed below, the proposed MBBR process will consume less energy than an equivalent mechanically-driven RBC process.

b) *Use energy in a more efficient way*: The MBBR blower energy is used for dual purposes, mixing and aeration. By reducing the reactor size, the MBBR mixing energy requirement is nominally equal to the oxygen supply (aeration) energy requirement, unlike conventional biological treatment processes, which require more energy for mixing larger tanks. The aeration energy alone is thus sufficient also to provide the necessary mixing. In addition, the MBBR biofilm carriers provide increased oxygen mass transfer efficiency, reducing oxygen supply requirements and subsequently energy requirements.

c) *Produce/utilize renewable energy*: The anaerobic digesters produce renewable energy in the form of biogas with a heat of combustion of approximately 650 BTU/cubic foot. The Selected Alternative goes well beyond normal biogas heat generation by employing a "*Waste-to-Energy*" process, which nearly triples the biogas production. The additional biogas is to be used to heat the digester reactors, digester building, and secondary building at the WRP site.

d) *Demonstrate new and innovative approaches*: MBBR is a new, innovative secondary treatment technology in Michigan. One MBBR system is in operation at this writing, located in Northport, Michigan. The existing secondary treatment consists of air-driven Rotating Biological Contactors (RBCs) that are beyond rated useful life and are no longer manufactured. The MBBR will provide for increased WRP capacity, reversing the decline in existing RBC treatment capacity caused by cumulative fouling of the RBC surface area. The Selected Alternative for this Project replaces the air-driven RBCs with an entirely new and innovative secondary treatment process, the MBBR. The MBBR has been shown to be a uniquely efficient and effective treatment.

Biogas as a Source of Clean Energy

The project goals include reduction of energy consumption by over 20% compared to conventional technologies in the replacement of the secondary aeration systems, reduction of greenhouse gas emissions, and reduction of the consumption of utility-purchased natural gas by 50%.

Currently, the WRP utilizes a high-rate anaerobic digestion process to stabilize biosolids (sludge) generated during the treatment process. The WRP captures the biogas generated through this process and utilizes it to fuel a boiler. Hot water heating is the most cost effective use of biogas energy for a WRP with influent flow rates less than five million gallons per day (MGD) in size.[5] Hot water produced in the boiler is used to provide heat to the digester tanks and buildings throughout the WRP/DPW campus. Historically, the heating demand during the winter has exceeded the amount of heat energy recovered from the digestion process. This additional heating demand is met by purchasing natural gas to supplement the biogas boiler fuel supply.

Because the WRP is operating below rated capacity, there is excess capacity in the anaerobic digesters. The proposed project includes modifications to the existing biosolids handling process to allow local food processor(s) to bring their high organic strength waste streams to the WRP for treatment. The high strength waste streams would be fed to the high rate anaerobic digester.

Research indicates that more biogas is produced per pound of food waste fed to an anaerobic digester than the amount of biogas produced from digestion of municipal biosolids.[6]

The target feed rate of food waste is 2,100 lb COD/day. It is anticipated that this amount of food waste fed to the anaerobic digesters will increase the biogas production from 80 CCF (hundred cubic feet) per day to approximately 220 CCF per day. This increase in renewable biogas fuel is anticipated to reduce the need of utility purchased natural gas by 91 CCF on cool days, which equates to an annual savings of $25,700 at 2011 natural gas prices.[8]

The pre-design budgetary cost of the Waste-to-Energy system is $80,400. The payback period for the system was calculated to be approximately 3-5 years. The payback estimate is based on current 2011 natural gas price projections.[8]

In addition to increasing biogas production, the City staff intends to improve energy efficiencies with this project, specifically, to further decrease their natural gas consumption by increasing heating efficiencies in the hydronic heating loop. This can be accomplished by optimally reducing the boiler operating temperature, therefore reducing the temperature in the hydronic loop, which directly reduces heat loss to the environment.

Reduction in Greenhouse Gas Emissions

Recent legislation from the US Senate aims to cut emissions of carbon dioxide and other heat-trapping greenhouse gases by 17 percent by 2020.[7] Additionally, the Obama Administration acknowledges that the reduction of greenhouse gas emissions is important to limiting global climate change, and has made cutting greenhouse gases a priority for the United States[8].

High rate anaerobic digesters have been shown to allow for capture of over 30% more methane, a greenhouse gas over 20 times worse than CO_2, compared to conventional biosolids management.[9]

Energy Efficient Treatment Technology

This Project incorporates an innovative and energy efficient MBBR secondary treatment technology. As demonstration of the Energy Efficiency, refer to an article comparing five modern wastewater treatment technologies demonstrating that use of MBBR technology for carbonaceous treatment had the lowest cumulative carbon footprint (i.e. energy consumption) of the modern and available treatment technologies reviewed.[10] MBBR technology utilizes smaller aeration basins than other treatment technologies, which translates to a lower energy requirement for aeration and mixing (see detail, above). In addition, this Project incorporates dissolved oxygen monitoring and variable speed control of the MBBR blowers so that the WRP operations staff will be able to fine-tune blower operation and maximize energy efficiency.

Comparison of MBBR vs. Mechanical RBC upgrade

As detailed in the SRF Project Plan (May 2009) and 2011 Supplement, the existing secondary treatment process, air-driven RBCs, are beyond their useful life and are no longer manufactured or supported. It is no longer possible to purchase replacement parts for this equipment. Some aging air-driven RBC plants are replacing air-driven equipment with mechanically-driven RBCs; most are deploying different treatment processes. Both of these options were evaluated in detail in the SRF Project Plan.

The RBC process is an older type of attached growth technology as was utilized frequently in the 1980s and early 1990s. Recently, RBC manufacturers and design professionals have recognized that RBC media is prone to plugging by debris commonly found in wastewater, thereby diminishing the effective surface area of the media over time. Because of this phenomenon, the RBC design loading criterion has been reduced, meaning that more media surface area is required per pound of BOD to be treated. [11] Due to the change in design criteria, replacement of the existing air-driven RBC equipment with mechanical RBC technology would require not only the replacement of the existing air-driven RBC equipment (shafts, media, etc) but would also require the construction and use of one entirely new mechanically-driven RBC train.

The proposed MBBR would utilize approximately 52 operating, or brake horsepower (BHP) to accomplish oxygen transfer for BOD treatment and mixing of the tank contents at the full capacity of the process, 1.3 MGD. This corresponds to an electricity usage of 339,000 kWh/year.

A corresponding three-train mechanical RBC plant would utilize approximately 66 BHP to rotate the media/shaft assembly and provide oxygen for BOD treatment for the same 1.3 MGD capacity. This corresponds to 428,200 kWh/year.

The proposed MBBR process saves about 89,200 kWh/year in electrical usage, corresponding to $8,900 per year at an electricity cost of $0.10/kWh, as follows:

Calculations

Energy Reduction (electrical):

$$428{,}200 \text{ kWh / yr} - 339{,}000 \text{ kWh / yr} = 89{,}200 \text{ kWh / yr}$$

Cost Reduction:

$$89{,}200 \text{ kWh / yr} \times \$0.10 \text{ / kWh} = \$8{,}900 \text{ / yr}$$

The capital costs for an MBBR and the RBC replacement/upgrade are essentially the same. Therefore, no capital payback period is required. The City will achieve electrical savings of approximately $8,900 annually at WRP capacity.

Components Qualifying for Green Project Reserve

As noted in the Guidance, this categorical, substantial energy conservation is accomplished by the MBBR processes in conjunction with the reuse of primary clarification enhanced anaerobic digestion processes at the WRP. The pre-design budgetary cost estimate of the MBBR process is $2.69 million and $85,200 for the *Waste-to-Energy* component, for a total project cost (green portion) of $2.78 million.

References

[1] Michigan DNRE. "2010 Clean Water and Drinking Water State Revolving Fund 20% Green Project Reserve: *Guidance for Determining Project Eligibility*" April 21, 2010

[2] Mark Steichen, Andy Shaw, Anjana Kadava, Patricia Scanlan, Mark Martin, Saeed Kazemi. *Carbon Footprinting of Wastewater Treatment Technologies.*

[3] United States Environmental Protection Agency. Wastewater Treatment Fact Sheet: Fine Bubble Aeration. EPA 832-F-99-065 September 1999.

[4] Metcalf & Eddy, "Wastewater Engineering" *Treatment and Reuse.* Fourth Edition. 2003. Pages 747, 955.

[5] United States Environmental Protection Agency. "Combined Heat and Power Energy Savings and Energy Reliability for Wastewater Treatment Facilities." March 5, 2008 http://www.epa.gov/chp/documents/wastewater_fs.pdf

[6] US EPA. "The Benefits of Anaerobic Digestion of Food Waste at Wastewater Treatment Facilities." Available online 7/19/2011 at URL: www.EPA.gov/region9/organics/ad/Why-Anaerobic-Digestion.pdf.

[7] Associated Press. "EPA moves to regulate industrial greenhouse gases." *MSNBC Environmental News.* 5/13/10. Available online 5/21/10 at URL http://www.msnbc.msn.com/id/37132292/ns/us_news-environment

[8] Associated Press. "Obama Administration agrees on greenhouse gas cuts." *Cleveland Ohio Business News.* 7/8/09. Available online 7/22/09 at URL: http://www.cleveland.com/business/index.ssf/2009/07/obama_administration_agrees_on.html

[9] United States Environmental Protection Agency. "Methane." March 5, 2010 http://www.epa.gov/methane

[10] Mark Steichen, Andy Shaw, Anjana Kadava, Patricia Scanlan, Mark Martin, Saeed Kazemi. *Carbon Footprinting of Wastewater Treatment Technologies.*

[11] Metcalf & Eddy, "Wastewater Engineering" *Treatment and Reuse.* Fourth Edition. 2003. Page 933.

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GPR Components Cost Estimate - Selected Alternative No. 5

Client: City of Plainwell
Project: Wastewater System Improvements

Project No: 802780
Date: July 2011

Description. Collection System Improvements; Replace Existing RBC Treatment System with MBBR Technology

Item	Item Description	Unit	Qty.	Unit Price	Amount
1	**Mixed Bed Biofilm Reactor (MBBR) Process & Clarifier Upgrades**				
	Fence Modifications	LS	1	$5,000	$5,000
	NPW Well Replacement	LS	1	$10,000	$10,000
	Dewatering	LS	1	$25,000	$25,000
	MBBR Basins - Excavation & Restoration	LS	1	$54,800	$54,800
	MBBR Basins - Concrete	LS	1	$431,100	$431,100
	Grating	SF	200	$20	$4,000
	Handrail	LF	450	$40	$18,000
	MBBR Equipment (Media, Screens, Air Headers/Laterals/Diffusers)	LS	1	$550,000	$550,000
	MBBR Equipment Installation	LS	1	$110,000	$110,000
	MBBR Blowers	EA	4	$25,000	$100,000
	Blower Building	SF	450	$90	$40,500
	Roofing	LS	1	$7,500	$7,500
	Blower Building HVAC	LS	1	$10,000	$10,000
	Painting/Coatings	LS	1	$50,000	$50,000
	Process Piping & Valves	LS	1	$120,000	$120,000
	Inlet Weirs	EA	3	$2,500	$7,500
	Effluent Weir Gate	LS	1	$8,000	$8,000
	Electrical/Controls	LS	1	$85,000	$85,000
	SCADA Upgrades	LS	1	$20,000	$20,000
	Secondary Clarifier Stamford Baffle Equipment	LS	1	$22,000	$22,000
	Secondary Clarifier Stamford Baffle Installation	LS	1	$5,500	$5,500
2	**Modifications for High Strength Waste Acceptance**	LS	1	$50,000	$50,000
				Construction Subtotal:	**$1,733,900**
3	**Prevailing Wages (Davis-Bacon)**				**$138,700**
4	**General Conditions, Mobilization, Contractor OH&P**				**$260,100**
				Construction Total:	**$2,132,700**
	Non-Construction Project Costs				
	Project Planning, Design, and Construction Engineering			$	486,990
				Project Cost Subtotal:	**$2,619,690**
				Project Contingency $	157,200
				Total Project Cost (FY2012):	***$2,777,000***

Plainwell WRP SRF Project
Green Project Reserve Calculations
Updated July 2011

Renewable Energy from Biogas			
Existing Biogas Production: (CCF / day)	80	CCF	*hundred cubic feet*
Waste-to-energy Production: (CCF / day)	140	MCF	*thousand cubic feet*
TOTAL Biogas Produced: (CCF/day)	220	SCF	*standard cubic feet*
Biogas Heat Content (BTU / CF)	650		
Nat. Gas Heat Content (BTU / CF)	1000		
Nat. Gas Price ($ / MCF)	$11.31		
Waste-to-Energy Component Cost	$85,200		
	Waste-to-Energy		
Biogas Fuel Value (MBTU / day)	9		
Utility Nat. Gas Reduction (SCF / day)	9,100		
Nat. Gas Cost Savings ($ / day)	$102.92		
Nat. Gas Cost Savings ($ / year)	$25,730		
Payback Period (simple calculation):	3.3 years		

Plainwell SRF Project
Green Project Reserve Demonstration
MBBR vs. Mechanical RBC Energy Calculations

6/18/2010
EJV

MBBR Aeration Requirement =	51.9	BHP (operating at plant capacity, 1.3 MGD)
	338,880	kWh/yr
	$ 33,888	per year
RBC Shaft Motors =	36.0	BHP, at 1.3 MGD plant capacity
RBC Suppl. Aeration Req'd =	29.6	BHP
Total Operating Electrical =	65.6	BHP
	428,192	kWh/yr
	$ 42,819	per year
MBBR % reduction in electrical =	**20.9%**	
Annual electrical cost savings =	$ 8,931	